7a
ARS 72-31
December 1964
5c

3

THE DEVELOPMENT OF COTTON FLOTE, A NEW TREATED COTTON BATTING

+L3a

5b

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE

THE DEVELOPMENT OF COTTON FLOTE, A NEW TREATED COTTON BATTING[1]

3a

by

Nestor B. Knoepfler
Southern Regional Research Laboratory[2]
New Orleans, Louisiana

INTRODUCTION

The history of cushioning materials from the saddle through the buggy, the horseless carriage, and the automobile verifies the fact that the widespread use of cotton for cushioning in modern automobiles is not happenstance.

It should be emphasized that everyone has his own subjective criteria for a good comfortable cushion. Some prefer softness, some prefer firmness; stylists prefer versatility, conformance to shape, and the like. In the final analysis, seating comfort is a subtle combination of these and many other factors.

Cotton offers properties that cover the greatest range of personal preferences; at the same time cotton has certain physical properties that are conducive to cushion comfort regardless of the degree of softness or firmness. A few of these properties are its absorptive characteristics, its ability to breathe when fabricated into pads or batts, its resistance to oxidative damage, its compatibility with a wide variety of upholstery fabrics, its damping effect on road shock and vibration when used in automobile cushions. The first buggy and horseless-carriage seat cushions were made using staple cotton. Obviously with the price of staple cotton at about 30¢ per pound this would be impossible on today's market. Many years ago a compromise was made wherein the use of linters to replace staple cotton in cushions became acceptable. This change was for the better because linters are much shorter than staple cotton fibers, and much greater in diameter; thus linters provide greater inherent resilience.

Once this substitution was made the garnetting industry needed something to tie the webs together to give a degree of integrity and coherence to the product. Here again the search for a lower priced material than staple cotton resulted in the selection of cotton spinning wastes which, although having very little resilience in themselves, served a useful purpose in the construction of cotton seating cushions. Gradually cotton byproducts, such as motes, fly, sweeps, picker, came to be acceptable in the fabrication of cotton batting, as exemplified by automobile seating cushions.

3b

1/ Presented at a meeting of the Seating Committee, Society of Automotive Engineers, Chicago, Ill., June 9, 1964.

2/ One of the laboratories of the Southern Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

It is apparent that now, unlike the early days, all raw materials used in cotton batting are byproducts from other cotton processes. Furthermore, the tendency of batting manufacturers to cut corners wherever possible to meet the demands of the automobile manufacturers for reduced prices has only compounded the inherent problems of cotton batting by introducing even lower grades of raw materials into the products.

The development of Cotton Flote[3/] was foreshadowed when in July 1961, a group of four trade organizations approached the Southern Regional Research Laboratory of the USDA with the request that the U.S. Department of Agriculture undertake research to develop an improved cotton batting product. These groups, The National Cotton Batting Institute, The Textile Waste Association, The National Cottonseed Products Association, and The Foundation for Cotton Research and Education, are supplying part of the funds for this research.

Most seating engineers are aware of the improvement that can be brought about in performance in textile fabrics for upholstery and trim through the application of chemistry to fibers. Chemical technology of this nature had never, previous to the present research, been concerned with cotton batting fibers.

RESEARCH

Research Approaches

Both manufacturers and consumers were consulted as to the improvements needed in cotton batting to better serve their requirements in cushioning applications. The consensus was that cotton batting must have: (a) a textile structure with better thickness retention, (b) more resilience in both the individual and the bulk of fibers, (c) improved cohesiveness, structural and dimensional stability, (d) higher bulk with less weight, (e) greater and more rapid recovery from deformation loading, and (f) new forms requiring little or no manual labor in the manufacture of end products (11, 12, 13, 14).[4/]

In addition to these necessary qualities, cotton batting was also stated to need a large number of secondary qualities. In regard to certain end-uses these additional qualities were considered to be equally or more important. Examples are lack of odor, low oil content, low moisture absorption and desorption, good color, minimum trash, resistance to micro-organisms, and fire or flame retardance.

Consideration of all of these requirements resulted in a research program designed to enhance the performance of cotton batting by use of: (a) resins or other chemical treatment designed to improve the resilience of the individual fibers and/or the bulk of fibers as they occur in a batt; (b) adhesives or bonding agents to obtain the desired amount of dimensional stability and coherence; (c) mechanical or chemical means of crimping, curling, kinking, or

---

3/ Trademark applied for by The National Cotton Batting Institute, The Textile Waste Association, The National Cottonseed Products Association, and The Foundation for Cotton Research and Education.

4/ Underscored numbers in parentheses refer to References at end of this paper.

interlocking the fibers to accomplish dimensional stability and coherence simultaneously with improved resilience; (d) mechanical approaches that would permit the orientation of fibers in a more random fashion than is possible with conventional garnetting; and (e) combinations of the above (12, 13).

The development of products engineered to specific end-uses was contemplated because cotton batting goes into a wide variety of products in which wide ranges of properties are essential.

The Process

Exploratory research was carried out to establish the feasibility of several means of applying chemical treatment to commercially produced cotton batting. The results confirmed expectations that treatment by immersion of the finished batt in a solution was not promising. Inherent difficulties in mechanical processing were encountered, such as uneven penetration of the batt by the treating solution, excessive matting, and compression of the structure. The performance characteristics of the products as well as the processing economics were considered poor.

Spray application of the treating media appeared to be a promising alternative technique. If reasonable uniformity in the distribution of the chemicals was desired, it was obvious that treatment of a finished batt would not be feasible. Accordingly, the mechanical processing operations were examined to ascertain at which point in the manufacture of batting the treatment could be applied by a spray technique which would assure the greatest portion of the fibers being processed would be uniformly exposed to the chemical reactants. The location selected was on the apron, where the web travels from the garnett to the lapper. Here the cotton is openly arrayed in a structure of minimum thickness and fiber accessibility which seems to offer the best condition for obtaining uniform dispersion of the treating solution throughout the material. Furthermore, at this location, under experimental conditions, the spray solution need be applied to only one side of the web. This was possible because during subsequent conventional lapping of the webs to form batts they could be laid down wet to dry surfaces, thus permitting some transfer of treating solution between adjacent surfaces. Commercial adaptation of the process has subsequently shown that spraying both sides of the web has some advantages.

Atomization of the treating solution to form small discrete droplets that will be dispersed onto the cotton with reasonable uniformity is an important part of the process.

A statistically designed series of experiments demonstrated that the ratio of resin to latex solids should be about 50-50, that the treating solution should contain about 20% solids, and that the wet add-on of the fibers should range from 85-100% (11).

Essentially then, the process as developed consists of a spray application of resin and latex in solution or suspension onto openly arrayed cotton web; conventional lapping and batt formation; and drying and curing (12, 13)[6/]

6/ U.S. Patent applied for.

The cotton batting industry has repeatedly asked why a wet process was selected. Much basic information on changes that can be achieved in cotton by the use of resins and other chemical compounds is available from research carried out at the Southern Regional Research Laboratory and elsewhere. An examination of this data indicates that fiber properties such as resilience are usually improved to the greatest extent by wet processing (12, 13). One of the basic reasons for this is that the reacting chemicals are actually absorbed into the cellulose molecules of the cotton. Under proper conditions of drying and curing, they are combined with the cellulose chemically. The chemical and physical properties of the fibers are thus permanently altered. This chemical phenomenon is known as crosslinking and occurs as a kind of bridging or structural reinforcing within the molecules of the cellulose.

The use of dry powders to achieve an improvement in the performance of cotton batting also received some attention in this research program. Wherever dry powders are used, significant improvement in the coherence and structural stability of the cotton batting products can be observed, but very little is achieved in the way of improved resilience and rapidity of recovery from compressive loading. This is what should be expected since microscopic examination of such products shows that a predominantly surface reaction or coating occurs. Such surface changes are basically interfiber rather than intrafiber and are not accompanied by structural-chemical changes in the cellulose molecules.

It should be made clear at this point that the above discussion is meant in no way to be critical of products made using dry powders. Previously it was stated that products from cotton batting should be engineered for specific end-uses. There are many applications in the automotive industry for the type of product made with dry techniques, and many other applications for products made with the wet system developed at the Southern Regional Research Laboratory.

The research leading to the process for the new product, now called Cotton Flote, was based on technical data available on resins normally used in conventional textile operations. Obviously with the wide difference in the raw materials used in textiles and in batting the translation was not as simple as might be supposed.

For textiles, the cotton is almost invariably preprocessed to remove much of the extraneous materials such as waxes, oil, and foreign matter such as hull dust, leaf and stem fragments, before resin or chemical treatments are attempted. In the case of cotton batting, the opposite is true. The cotton byproducts that serve as the raw material for batting have been culled from other processes and are highly suffused with all types of objectionable foreign matter, the removal of which is economically prohibitive.

Preliminary evaluation of the feasibility of using a spray technique for chemical application wherein water-soluble thermosetting resins were used showed that improved fiber resilience could be attained in this manner even with some of the extraneous and foreign materials present. The samples thus produced, however, demonstrated a lack of dimensional stability and coherence because of the essentially intrafiber character of the reaction of the thermosetting agent with the cellulose of the cotton. To improve the dimensional stability and coherence a latex, or film-forming thermoplastic resin, was included in the spray formulations to serve as a bonding agent between

fibers at points of contact. Briefly then, the thermosetting resins contribute improved resilience while the termoplastic resins or latexes contribute coherence.

Both thermosetting and thermoplastic resins were evaluated for their ability to crosslink with the cotton under the special conditions of their application to cotton batting. The criteria for the selection of resins and latexes to be evaluated in this work were that they be water soluble or suspendible, be mutually compatible to permit spray application from a single solution/suspension, have a reasonable pot life, be of low toxicity, and be relatively inexpensive. Other factors considered were the initial odor of the product, and the propensity of the resin to generate disagreeable odors after curing or storage.

Test Methods

The cotton batting industry and the consumers of batting have few standards for measuring the performance of the product. None of the tests used really describe the performance that can be expected from a given sample of cotton batting under conditions of actual use. As this research progressed, it was necessary to develop new tests and modify existing ones to objectively measure the performance of experimental products.

The use of resins and latexes in the treatment of cotton batting has made it necessary for the product to meet specifications which some consumers place on foam or plastic products. One such test is a measurement of the resistance of the material to set under conditions of high load and elevated temperature (2, 4), wherein the samples are compressed to 1/2 their original thickness and held at 158° F. for 22 hours. Upon removal from the oven samples are equilibrated for 30 minutes without load and the set due to heat is calculated from the formula:

$$S = \frac{H_o - H}{H_{\frac{1}{2}}} \times 100$$

where H_o = original height
H = height after 30 minutes
$H_{\frac{1}{2}}$ = compressed height
S = % set

Maximum permissible set for topper pads is 30% (6) for base pads 35% (5).[5/]

A test instrument was designed and used to measure the recovery performance of cotton batting after being subjected to cyclic compressive deformation (10).

A 16-square-inch circular sample of batting is subjected to 50 cyclic loadings at 1.0 lbs./sq.in. and the recovery calculated from the formula:

$$R = \frac{H_1}{H} \times 100$$

5/ 40% allowed by practice but not specifically stated in specifications.

where H = original height

H_1 = height immediately after 50th cycle

R = % recovery.

Curves over a period of recovery time can be constructed by H readings at given time intervals. To compete with foam in cushioning, cotton batting should have a recovery from such deformation loading in excess of 90% within 4 minutes of the completion of the 50th cyclic loading when tested at 65% relative humidity.

Cotton batting often finds use under conditions of high relative humidity, a situation in which it performs poorly in comparison with foams. To evaluate the new product under such conditions the loading feet of the test instrument were enclosed in plastic chambers in which the temperature and the humidity could be controlled accurately. Cyclic loading tests as described above are routinely carried out on experimental samples at 100% relative humidity. To be considered acceptable, a sample must have a recovery in excess of 80% within 4 minutes after the completion of the 50th cyclic loading when tested at 100% relative humidity.

The tensile or tear strength of untreated cotton batting is extremely low, on the order of 2 to 4 pounds in the direction of the fiber lay, and 1 to 2 pounds transverse to the fiber lay using the textile grab test (1) modified for cotton batting. To be acceptable, treated cotton batting must have a tear or break test strength in excess of 15 pounds in either direction. Experimental samples have been produced with tensile strengths of 60 pounds or more in the direction of the fiber lay and 24 or more pounds transverse to the fiber lay.

A test that has been used to index the performance of cushioning materials is the hysteresis loading-unloading curve technique, sometimes called the energy absorption test. In this procedure an Instron[6/] equipped with a "C" cell is used along with an integrator to measure the energy into and the energy returned by the sample. Samples being tested are subjected to 10 cyclic loadings at 25 pounds total load on a 16-square-inch sample (7). This test favors materials with a rapid, constant rate, recovery from compressive loading. Cotton batting's rate of recovery is rapid for only a small portion of its recovery, with the rate falling continually thereafter during the recovery period. The hysteresis loading test specifies a maximum of 30 inch-pounds for foam and 18 inch-pounds for cotton batting topper pads (8) and 19.5 inch-pounds for base or foundation pads (9). Some experimentally treated batts have equaled the values given for foam; however, in general, resin-treated batts that have good properties range between 22 and 24 inch-pounds.

In another test designed to measure indentation loading characteristics, the load is measured that is necessary to deflect the sample 25% of its original thickness. Textile assist is included, since a sample 12 by 12 inches is tested with a loading foot 8 inches in diameter (3). Loads specified for untreated cotton should not exceed 4 pounds (5, 6); however, resin-latex

---

6/ A product named by the U. S. Department of Agriculture in this paper does not imply approval or recommendation of the product to the exclusion of others which may also be suitable.

treated samples generally require from 5-1/2 to 8 pounds for the same 25% deflection at comparable densities.

An index of the service life of resin-latex treated cotton batting is obtained by using a pounding device which subjects a 16-square-inch sample to 132 compressive loadings per minute at the rate of 1-1/2 pounds per square inch. This is a modification of American Society for Testing Materials Test Method D1564-62T (3). Samples are compressed and relaxed at least 15,000 times. Compression set is measured and expressed in terms of percent of original height lost. To successfully pass this test a sample should not show more than 20% loss in height immediately on completion of the test, and should show not over 10% permanent set 24 hours later.

SUMMARY OF RESULTS

Cotton batting having improved resilience and dimensional stability has been made on a pilot-plant scale using combinations of resins and latexes.

This research has established that it is feasible to apply certain resins and latexes to cotton batting while it is in the web form by spraying the reactants onto the web on the apron discharge from the garnett. By proper selection of the resins and latexes, certain systems that are compatible with each other in the solution or suspension to be sprayed have been derived. Pot lives of these solution-suspension systems are sufficiently long to be commercially useful on a production basis. Under the selected conditions a single spray operation accomplishes the application of the two or more chemicals needed to treat the batting.

Products having different resiliences and densities are envisioned for specific end-uses. Selection of thermoplastic and/or of thermosetting resins for a given product will depend upon the performance requirements of the specific end-use. For thermoplastics, low temperatures that accomplish drying are usually sufficient to cure the resin; however, good heat stability is not achieved. For thermosetting resins, temperatures in the range of 300° F. are generally needed to accomplish curing, and products demonstrate better tolerance to high load at high temperature.

Experimental products demonstrate more rapid and more complete recovery from deformation loading under conditions of 65% relative humidity and temperatures of 72°-78° F.--about 90%-95% within 4 minutes, as well as under conditions of 100% relative humidity and temperatures of 78°-84° F. with recoveries of 80%-90% within 4 minutes. They have energy-absorption characteristics much improved over conventional cotton batting and up to 20-fold increase in tensile and tear strength.

The experimental products have been tested through as many as 15,000 cycles of loading and unloading. Of the samples tested, the greatest immediate "set" was 18.1% and the least 9.3%, compared with an average 40.6% "set" for conventional commercial cotton batting. After 24 hours' recovery the treated samples had "sets" between 3.3% and 11.3% compared with 29.7% for untreated commercial batting.

REFERENCES

1. American Society for Testing Materials. Standard Methods of Test for Breaking Load and Elongation of Textile Fabrics. D 1682-64 (1964)

2. American Society for Testing Materials. Standard Methods of Test for Compression Set of Vulcanized Rubber. D 395-61 (B) (1961)

3. American Society for Testing Materials. Tentative Specifications and Methods of Test for Flexible Urethane Foam. D 1564-62 T (1962)

4. Chrysler Corporation. Compression Set of Cotton and Hair Pads - Constant Deflection Method "B". Engineering Laboratory Procedure 463KB-5-01. (Dec. 30, 1960)

5. Chrysler Corporation. Cushion and Back Cotton Padding (Color Optional). Engineering Division Material Standard MS-JZ5-25. (May 14, 1956)

6. Chrysler Corporation. Cushion and Back White Cotton Padding. Engineering Division Material Standard MS-JZ5-23. (May 14, 1956)

7. Ford Motor Company. Energy Absorption of Padding Materials. Quality Laboratory & Chemical Engineering Physical Test Method BN 15-3. (Oct. 24, 1960)

8. Ford Motor Company. Cotton Padding Material. Manufacturing Standard MH M 17H65 A-E. (August 1960)

9. Ford Motor Company. Unbleached Cotton Padding Material. Manufacturing Standard MH M 17B64 A-G. (August 1960)

10. Gentry, W. T., Jr., Haydel, C. H., and Knoepfler, Nestor B. Simple Test Determines Compressional Set of Cotton Batts. Bedding 85(2): 41-44, 46. (Sept. 1963)

11. Knoepfler, Nestor B., Gardner, Homer K., Jr., and Vix, Henry L. E. Using Chemical Engineering to Improve Cotton Batting. Amer. Dyestuff Reptr. 53(24): (Nov. 23, 1964)

12. Knoepfler, Nestor B., Gardner, Homer K., Jr., Vix, Henry L. E., and Patton, Elmo L. Cotton Research Aims at Recapturing Batting Markets. Bedding 84(3): 40-44, 46, 48, 50. (Apr. 1963)

13. Knoepfler, Nestor B., Gardner, Homer K., Jr., Vix, Henry L. E., and Patton, Elmo L. Research on Cotton Batting. West. Furn. Mfg. 18(4): 18, 22-25. (May 1963)

14. Knoepfler, Nestor B., and Vix, Henry L. E. Recapturing Cotton Batting Markets by Chemical Engineering Research. Cot. Gin and Oil Mill Press 65(20): 28-32. (Sept. 1964)